
# GLAST Large Area Telescope

## Calorimeter Subsystem

## 10.0 Assembly & Test

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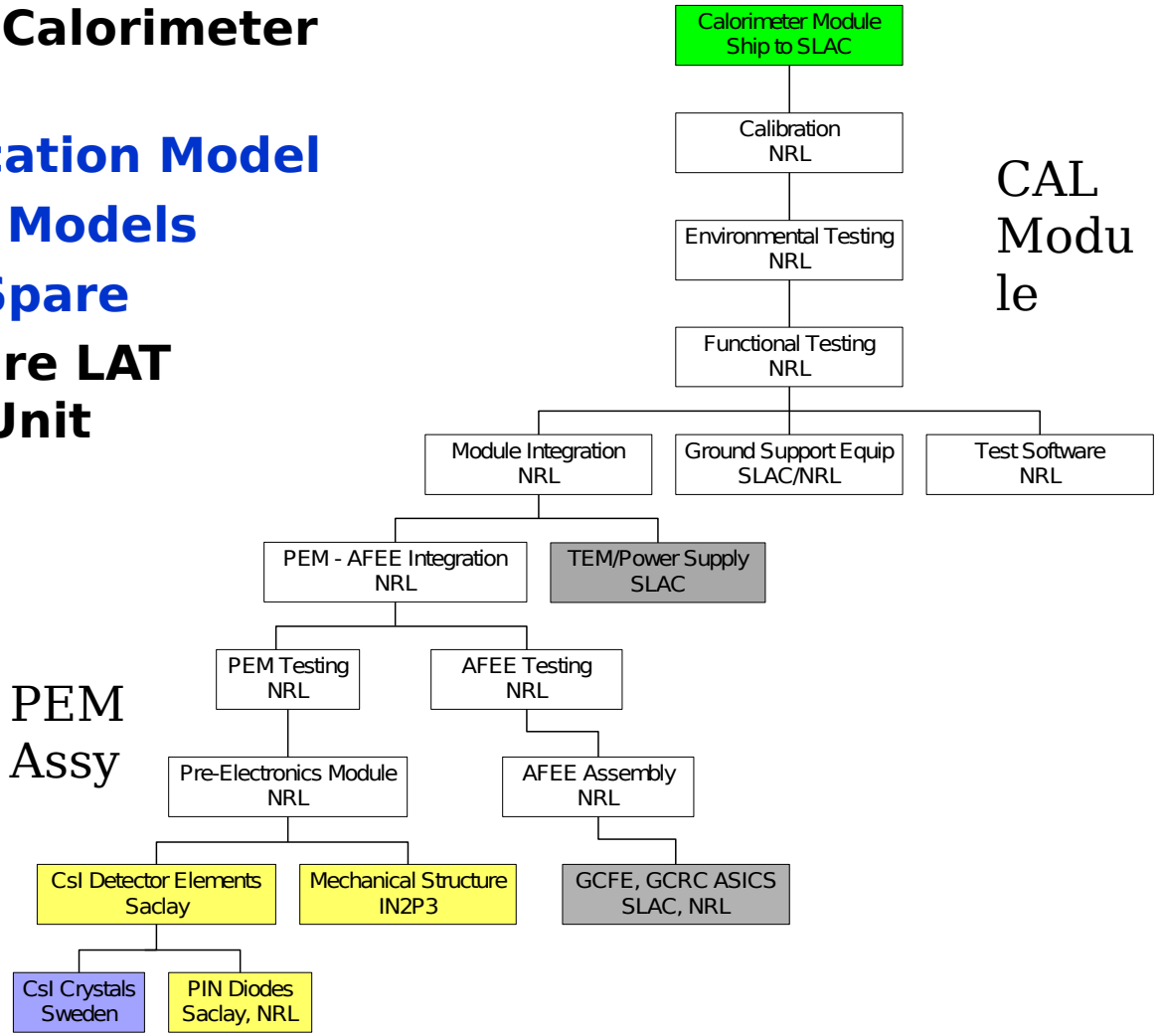
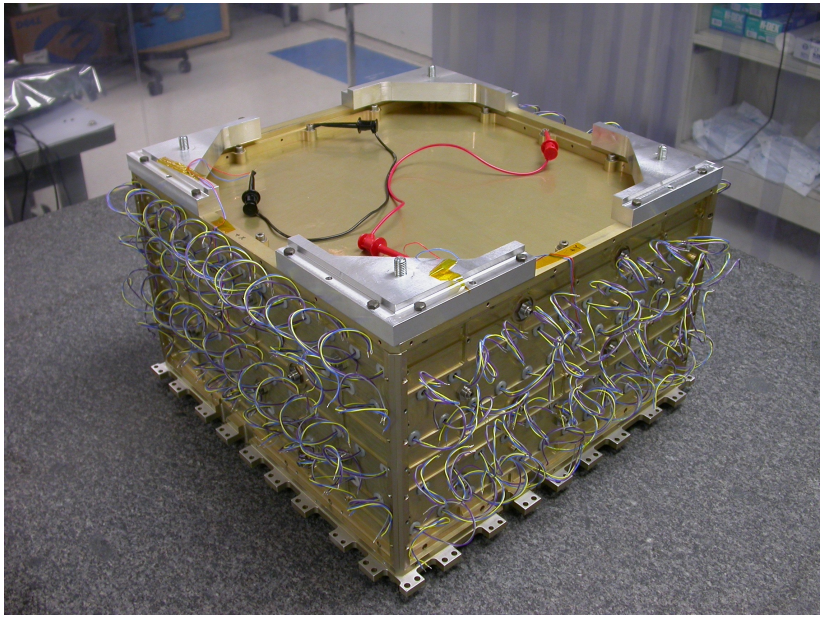
# Calorimeter Assembly Overview

- **18 Identical Calorimeter Modules**
  - **1 Qualification Model**
  - **16 Flight Models**
  - **1 Flight Spare**
- **1st 4 units are LAT Calibration Unit**

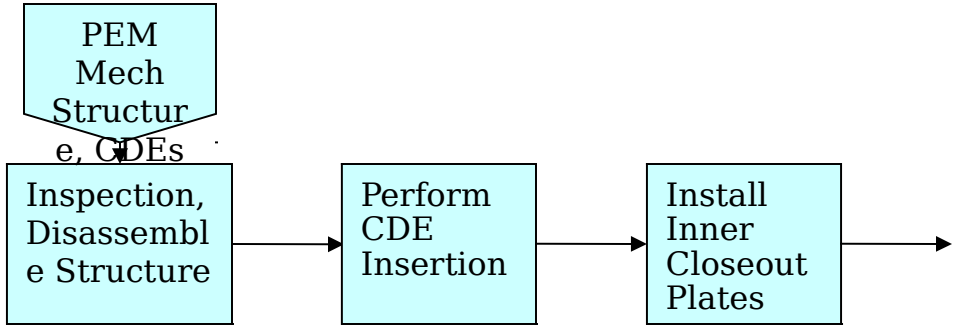


# PEM Assembly

- **Pre-Electronic Modules (PEM)**
  - **Assembly Performed by Naval Research Lab**
    - **Mechanical Structure, from IN2P3, France**
    - **Crystal Detector Elements, from CEA, France**
- **PEM Testing**
  - **Opportunity to uncover assembly issues prior to next level**
  - **Muon Testing verifies optical performance of CDEs**
  - **Failed CDEs could be replaced relatively easily at this stage of assembly**

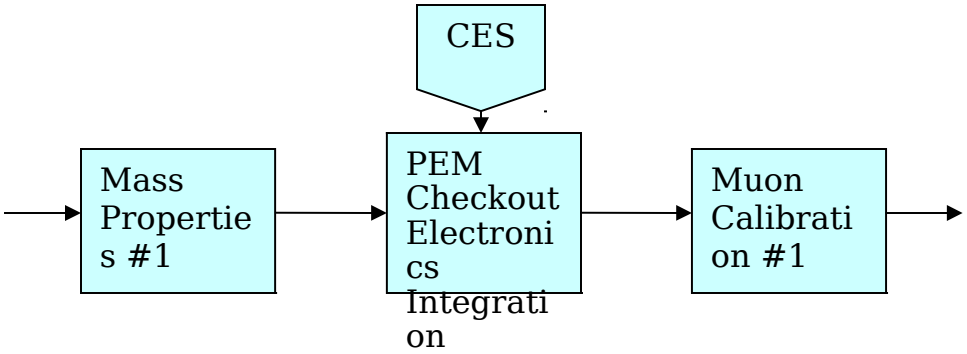


# PEM Assembly Flow



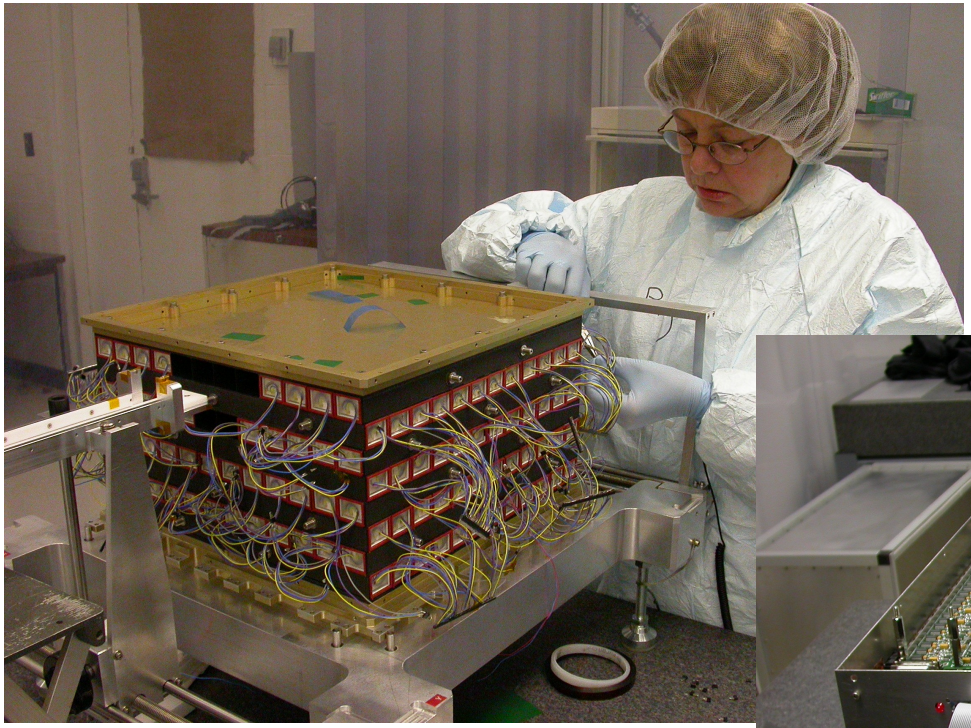

- **Goals**
  - **Inspect PEM Mechanical Structure, CDEs – verify dimensions**
  - **Assemble Pre-Electronics Module**
- **Inputs**
  - **PEM Mechanical Structure, Data book**
  - **Crystal Detector Elements, Data book**
  - **Elastomeric Cords & Bumper frames**
  - **Special MGSE: CDE Insertion tooling, Closeout Plate Integration tooling**
- **Outputs**
  - **Assembled PEM**
  - **PEM Assembly data book: CDE Identification and insertion locations**

# PEM Acceptance Tests

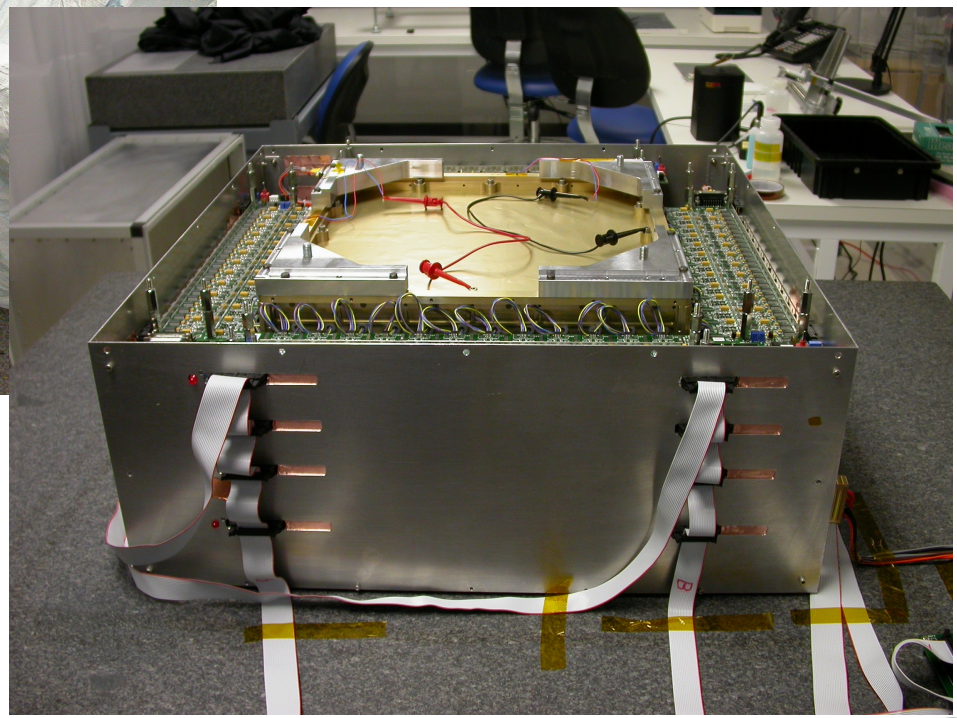



- **Goals**
  - **Inspect PEM, verify dimensions and weight**
  - **Verify that PEM meets light yield and light attenuation specs**
- **Inputs**
  - **Assembled PEM**
  - **PEM Data book**
  - **Special EGSE: PEM Checkout Electronics System (lab electronics, DAQ)**
- **Outputs**
  - **Accepted PEM**
  - **CsI light yield and light attenuation maps**

# PEM Assembly & Test



**Engineering Model CDE insertion nearing completion**

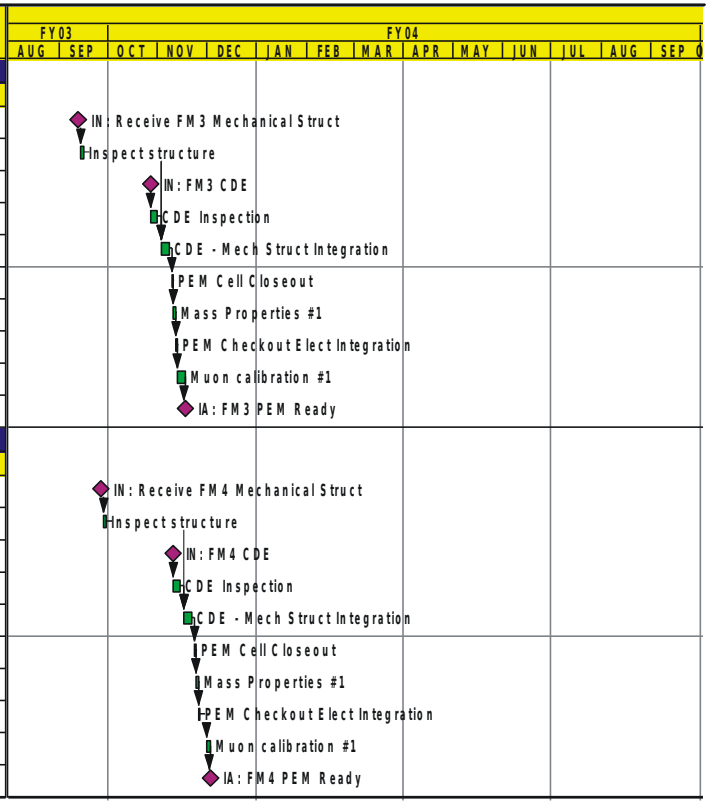


**Engineering Model PEM Muon Calibration test setup**

# PEM Assembly Schedule

## Level 3 Schedule – FM3 & FM4 PEM Assemblies

| WBS | Activity ID | Activity Description | Total Float | Orig Dur | Early Start | Early Finish |
|---|---|---|---|---|---|---|
| CAL FM3 | | | | | | |
| 4.1.5.6 PRE-ELECTRONICS MODULE (PEM) | | | | | | |
| 4.1.5.6.2.3.5 | 5C62300400 | IN: Receive FM3 Mechanical Struct | 102 | 0 | | 09/12/03 |
| 4.1.5.6.2.3.5 | 5C62300410 | Inspect structure | 102 | 1 | 09/15/03 | 09/15/03 |
| 4.1.5.6.2.3.5 | 5C62300420 | IN: FM3 CDE | 68 | 0 | | 10/27/03 |
| 4.1.5.6.2.3.5 | 5C62300430 | CDE Inspection | 68 | 4 | 10/28/03 | 10/31/03 |
| 4.1.5.6.2.3.5 | 5C62300440 | CDE - Mech Struct Integration | 68 | 5 | 11/03/03 | 11/07/03 |
| 4.1.5.6.2.3.5 | 5C62300450 | PEM Cell Closeout | 68 | 1 | 11/10/03 | 11/10/03 |
| 4.1.5.6.2.3.5 | 5C62300460 | Mass Properties #1 | 68 | 1 | 11/11/03 | 11/11/03 |
| 4.1.5.6.2.3.5 | 5C62300470 | PEM Checkout Elect Integration | 68 | 1 | 11/12/03 | 11/12/03 |
| 4.1.5.6.2.3.5 | 5C62300480 | Muon calibration #1 | 68 | 3 | 11/13/03 | 11/17/03 |
| 4.1.5.6.2.3.5 | 5C62300490 | IA: FM3 PEM Ready | 68 | 0 | | 11/17/03 |
| CAL FM4 | | | | | | |
| 4.1.5.6 PRE-ELECTRONICS MODULE (PEM) | | | | | | |
| 4.1.5.6.2.3.6 | 5C62300500 | IN: Receive FM4 Mechanical Struct | 103 | 0 | | 09/26/03 |
| 4.1.5.6.2.3.6 | 5C62300510 | Inspect structure | 103 | 1 | 09/29/03 | 09/29/03 |
| 4.1.5.6.2.3.6 | 5C62300520 | IN: FM4 CDE | 69 | 0 | | 11/10/03 |
| 4.1.5.6.2.3.6 | 5C62300530 | CDE Inspection | 69 | 4 | 11/11/03 | 11/14/03 |
| 4.1.5.6.2.3.6 | 5C62300540 | CDE - Mech Struct Integration | 69 | 5 | 11/17/03 | 11/21/03 |
| 4.1.5.6.2.3.6 | 5C62300550 | PEM Cell Closeout | 69 | 1 | 11/24/03 | 11/24/03 |
| 4.1.5.6.2.3.6 | 5C62300560 | Mass Properties #1 | 69 | 1 | 11/25/03 | 11/25/03 |
| 4.1.5.6.2.3.6 | 5C62300570 | PEM Checkout Elect Integration | 69 | 1 | 11/26/03 | 11/26/03 |
| 4.1.5.6.2.3.6 | 5C62300580 | Muon calibration #1 | 69 | 3 | 12/01/03 | 12/03/03 |
| 4.1.5.6.2.3.6 | 5C62300590 | IA: FM4 PEM Ready | 69 | 0 | | 12/03/03 |



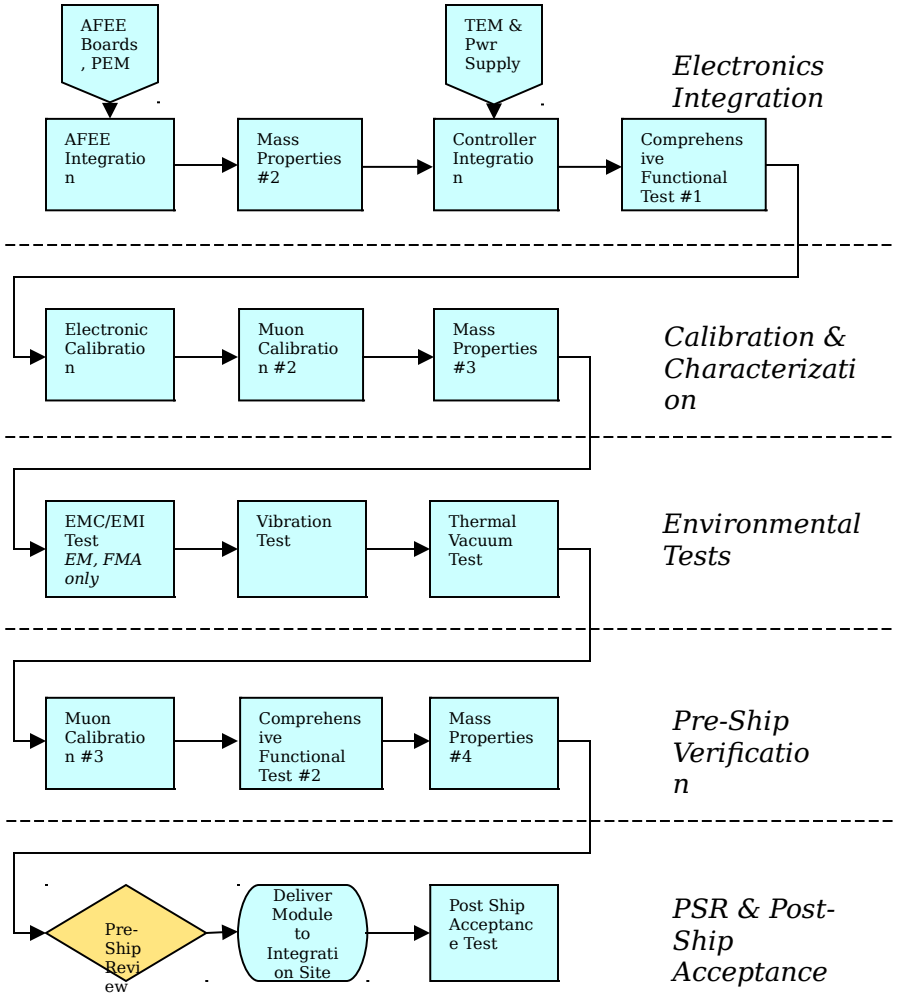
# Calorimeter Module Assembly

- **Assemble Calorimeter Tower Modules**
  - **Pre-Electronics Module**
    - **Assembled and Tested at NRL**
  - **Assemble & Test Analog Front End Elect (AFEE) boards**
    - **AFEE PWB Design, from SLAC**
    - **ASIC Designs, from SLAC**
  - **Tower Electronics Module & Power Supply, from SLAC**
- **Test**
  - **Functional Testing**
  - **Environmental Testing**
  - **Calibration**
- **Deliver to SLAC**
  - **Perform Acceptance Test**

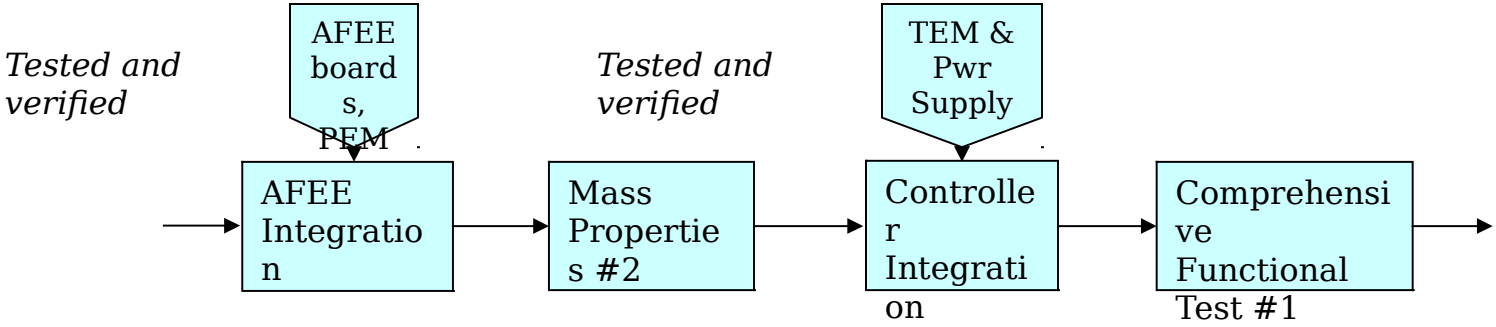
# Assembly and Test Flow

**Five stages in Assembly & Test sequence:**

1) **Electronics integration**
2) **Calibration, baseline**
3) **Environmental tests**
4) **Pre-ship verification**
5) **Delivery & Post-ship Acceptance**

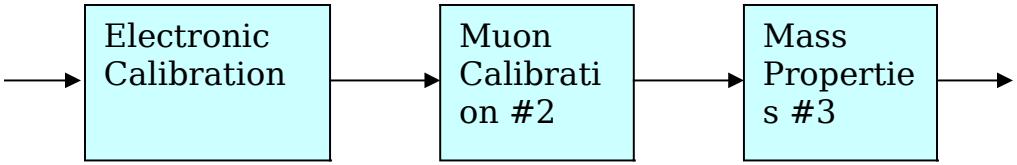


# Electronics Integration



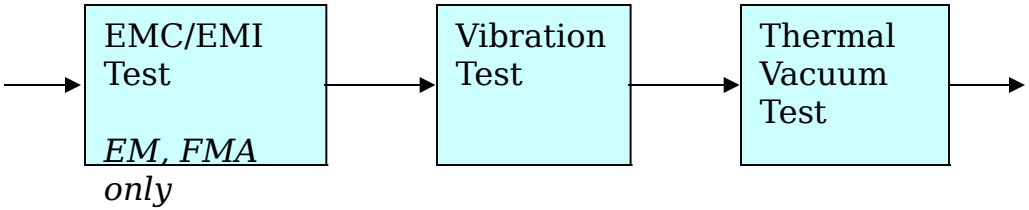

- **Goals**
  - **Integrate Flight Front-end electronics onto PEM**
  - **Integrate TEM Controller & Power Supply**
  - **Establish weight and physical dimensions of CAL Module**
  - **Establish baseline system performance**
- **Inputs**
  - **Verified PEM**
  - **Flight AFEE boards, previously tested and verified**
  - **EM/Flight TEM, previously tested and verified**
  - **EM/Flight Power Supply, previously tested and verified**
  - **Special GSE: Assembly/Rotation Stand, Calorimeter Test Stand (CTS)**
- **Output**
  - **Integrated, fully tested CAL Tower Module**

# Calibration & Characterization



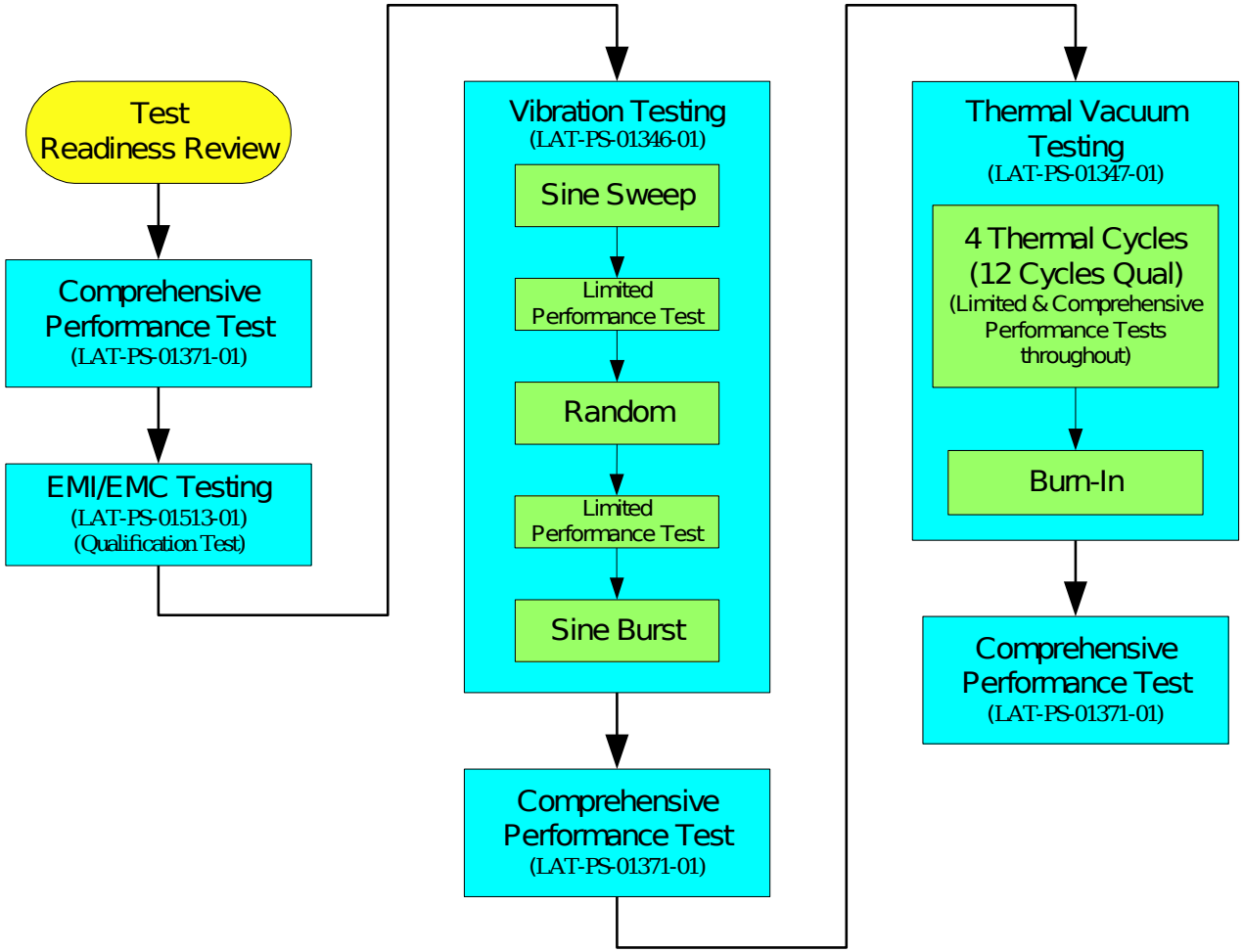

- **Goals**
  - **Establish baseline gain, linearity, and mass properties of integrated module**
- **Inputs**
  - **Integrated and fully tested CAL Tower Module**
  - **Special EGSE: Calorimeter Test Stand**
- **Output**
  - **768 electronic gain and linearity curves per Module**
    - **One for each energy range: 96 crystals × 2 faces × 4 ranges**
  - **384 optical gains per Module**
    - **One for each PIN: 96 crystals × 2 faces × 2 PIN Diodes**
    - **Optical gain is electrons in FE per MeV deposited in xtal**
  - **Mass, dimensions**
  - **Calibrated CAL Module**

# Environmental Tests

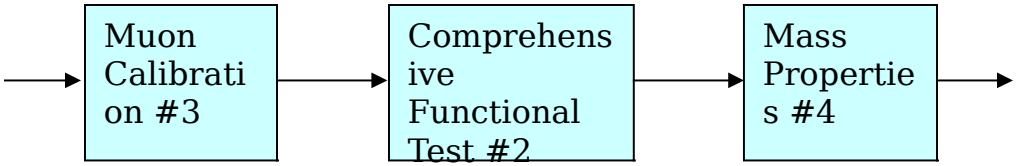



- **Goals**
  - **Ensure Module safety and performance against thermal, pressure, vibration, shock, and electromagnetic excursions expected during flight.**
- **Inputs**
  - **Fully functional, calibrated CAL Tower Module**
  - **Thermal-Vacuum, Vibration, EMC/EMI facilities at NRL**
    - **Note test levels vary as appropriate:**
      - **FMA: Qualification levels, EMC/EMI testing**
      - **FMB: Acceptance level Vibration, Qual level Thermal Vacuum**
      - **FM1-FM16: Acceptance levels**
  - **Special GSE: Vibration & Thermal-Vacuum fixtures, Calorimeter Test Stand**
- **Outputs**
  - **Environmentally Tested Flight Unit**

# Environmental Test Flow

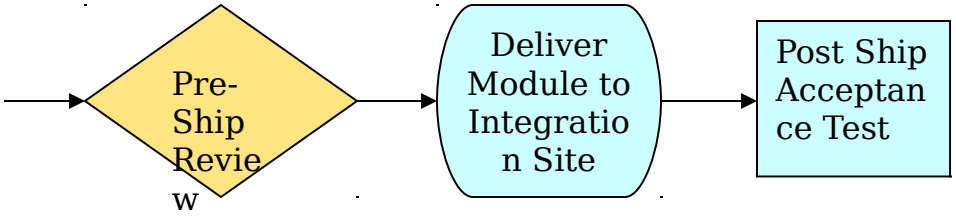


# Post Environmental Verification




- **Goals**
  - **Final verification of Cal Module for delivery**
- **Inputs**
  - **Fully Tested CAL Tower Module**
  - **Special GSE:  Calorimeter Test Stand**
- **Outputs**
  - **Verified CAL Module ready for Integration**
  - **Flight Documentation for Pre-Ship Review**

# Delivery & Acceptance




- **Pre-Ship Review**
  - **Review Board consists of Subsystem Manager, A&T Manager, Systems Engineer, QA Engineer, Lead Engineers, others as deemed necessary**
  - **Walk-through A&T flow, review Test Reports, Resolution Reports, status of all anomalies, etc**
- **Flight Unit Delivery**
- **Post-Ship Acceptance Test**
  - **Verifies functionality of delivered CAL Module**
  - **Formal Acceptance by LAT**

# Assembly and Test Schedule

## Duration of assembly and test phases (working days for *each* Module)

| Phase | Module | | | |
|---|---|---|---|---|
| | EM | FMA,FMB | FM1-6 | FM7-16 |
| Electronics Integration | 25 | 27 | 12 | 11 |
| Calibration | 12 | 6 | 5 | 4 |
| Environmental | 44 | 41 | 13 | 13 |
| Pre-ship Verification | 10 | 7 | 6 | 6 |
| Delivery & Acceptance | 12 | 12 | 12 | 12 |
| Total days per Module | 103 | 93 | 48 | 46 |

- Production is planned to begin on October 9 and continue until July 22, 2004
- One Module ships to LAT Integration Site (SLAC) every two weeks beginning with FMA on Feb 17, 2004
  - Two modules every two weeks for modules 7 thru 16
- During full production, up to ten modules will be in process at once
  - All assembly and test activities will operate in parallel
  - Electronics integration will be capable of handling several modules simultaneously

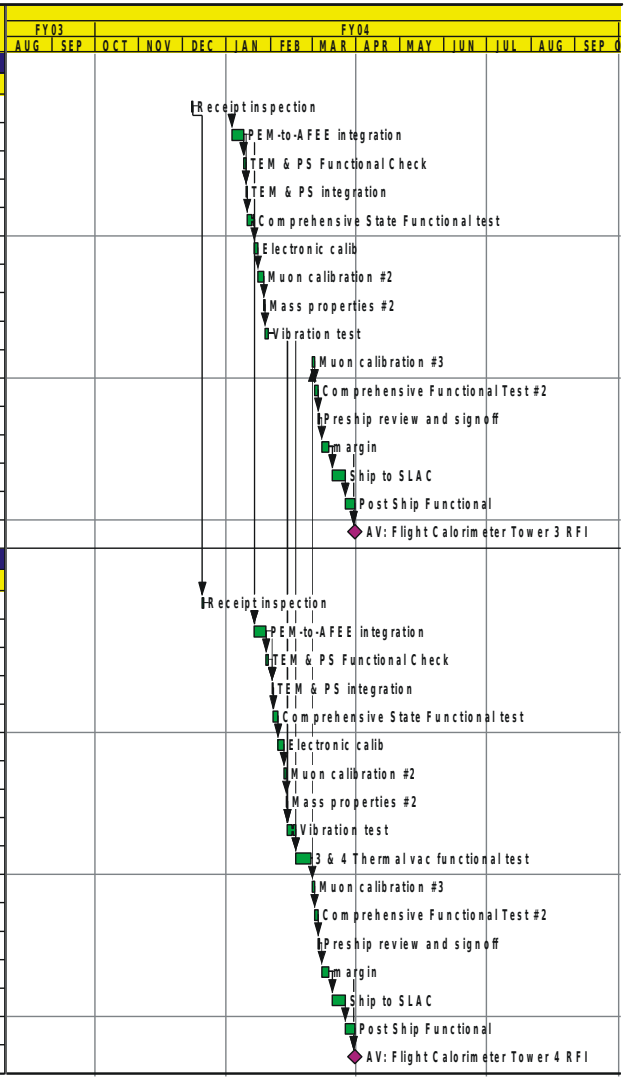
# Assembly and Test Schedule

- **Level 3 Milestones - Delivery for LAT Integration**
  - **CAL Flight Modules move through Assembly and Test in groups of 2**
    - **Modules are Thermal-Vacuum tested in pairs to save $$$**
  - **Instrument integration schedule specifies required Ready For Integration (RFI) dates**
  - **RFI rate:**
    - **FMA, FMB, FM1–FM6**
      - **One Module every two weeks**
    - **FM7–FM16**
      - **Two Modules every two weeks**

| Module | Planned Module Delivery Date | LAT Schedule Integration Date |
|---|---|---|
| Qual Model (FM A) | 17 Feb 04 | 17 Feb 04 |
| Flight Spare (FM B) | 17 Feb 04 | 17 Feb 04 |
| Flight Model 1 | 5 Mar 04 | 15 Mar 04 |
| Flight Model 2 | 8 Mar 04 | 15 Mar 04 |
| Flight Model 3 | 30 Mar 04 | 15 Jun 04 |
| Flight Model 4 | 30 Mar 04 | 15 Jun 04 |
| Flight Model 5 | 28 Apr 04 | 15 Jul 04 |
| Flight Model 6 | 28 Apr 04 | 15 Jul 04 |
| Flight Model 7 | 25 May 04 | 29 Jul 04 |
| Flight Model 8 | 25 May 04 | 29 Jul 04 |
| Flight Model 9 | 9 Jun 04 | 12 Aug 04 |
| Flight Model 10 | 9 Jun 04 | 12 Aug 04 |
| Flight Model 11 | 22 Jun 04 | 26 Aug 04 |
| Flight Model 12 | 22 Jun 04 | 26 Aug 04 |
| Flight Model 13 | 7 Jul 04 | 10 Sep 04 |
| Flight Model 14 | 7 Jul 04 | 10 Sep 04 |
| Flight Model 15 | 22 Jul 04 | 24 Sep 04 |
| Flight Model 16 | 22 Jul 04 | 24 Sep 04 |

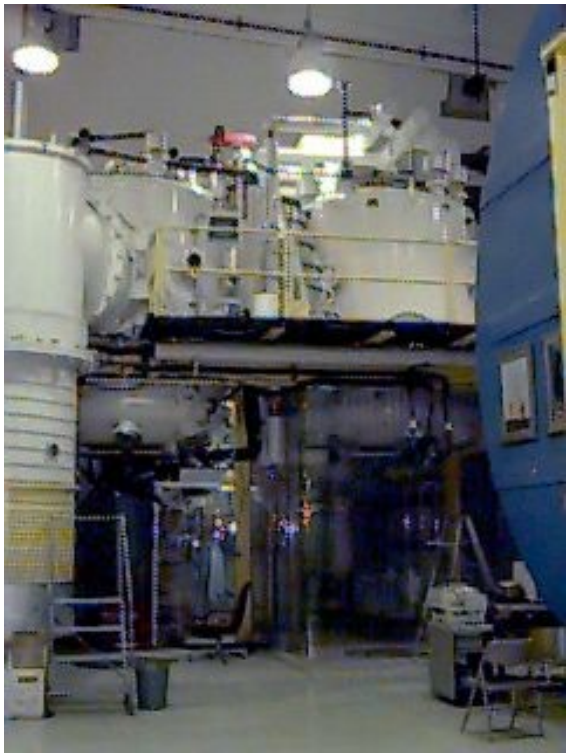
# Flight Module 3 & 4 – Assembly & Test

| WBS | Activity ID | Activity Description | Total Float | Orig Dur | Early Start | Early Finish |
|---|---|---|---|---|---|---|
| CALFM3 | | | | | | |
| 4.1.5.9 CALORIMETER MODULE ASSEMBLY,TEST & CAL | | | | | | |
| 4.1.5.9.2.5 | 5C1219 | Receipt inspection | 56 | 1 | 12/08/03 | 12/08/03 |
| 4.1.5.9.2.5 | 5C1223 | PEM-to-AFEE integration | 44 | 6 | 01/05/04 | 01/12/04 |
| 4.1.5.9.2.5 | 5C1223B | TEM & PS Functional Check | 62 | 2 | 01/13/04 | 01/14/04 |
| 4.1.5.9.2.5 | 5C1224 | TEM & PS integration | 62 | 1 | 01/15/04 | 01/15/04 |
| 4.1.5.9.2.5 | 5C1225 | Comprehensive State Functional test | 62 | 2 | 01/16/04 | 01/20/04 |
| 4.1.5.9.2.5 | 5C1226 | Electronic calib | 62 | 2 | 01/21/04 | 01/22/04 |
| 4.1.5.9.2.5 | 5C1227 | Muon calibration #2 | 62 | 2 | 01/23/04 | 01/26/04 |
| 4.1.5.9.2.5 | 5C1228 | Mass properties #2 | 62 | 1 | 01/27/04 | 01/27/04 |
| 4.1.5.9.2.5 | 5C1230 | Vibration test | 62 | 3 | 01/28/04 | 01/30/04 |
| 4.1.5.9.2.5 | 5C1231 | Muon calibration #3 | 54 | 2 | 03/01/04 | 03/02/04 |
| 4.1.5.9.2.5 | 5C1232 | Comprehensive Functional Test #2 | 54 | 2 | 03/03/04 | 03/04/04 |
| 4.1.5.9.2.5 | 5C1233 | Preship review and signoff | 54 | 1 | 03/05/04 | 03/05/04 |
| 4.1.5.9.2.5 | 5C1234 | margin | 54 | 5 | 03/08/04 | 03/12/04 |
| 4.1.5.9.2.5 | 5C1234A | Ship to SLAC | 54 | 7 | 03/15/04 | 03/23/04 |
| 4.1.5.9.2.5 | 5C1234B | Post Ship Functional | 54 | 5 | 03/24/04 | 03/30/04 |
| 4.1.5.9.2.5 | 5C1235 | AV: Flight Calorimeter Tower 3 RFI | 54 | 0 | | 03/30/04 |
| CALFM4 | | | | | | |
| 4.1.5.9 CALORIMETER MODULE ASSEMBLY,TEST & CAL | | | | | | |
| 4.1.5.9.2.6 | 5C1239 | Receipt inspection | 62 | 1 | 12/15/03 | 12/15/03 |
| 4.1.5.9.2.6 | 5C1243 | PEM-to-AFEE integration | 44 | 6 | 01/21/04 | 01/28/04 |
| 4.1.5.9.2.6 | 5C1243B | TEM & PS Functional Check | 53 | 2 | 01/29/04 | 01/30/04 |
| 4.1.5.9.2.6 | 5C1244 | TEM & PS integration | 53 | 1 | 02/02/04 | 02/02/04 |
| 4.1.5.9.2.6 | 5C1245 | Comprehensive State Functional test | 53 | 3 | 02/03/04 | 02/05/04 |
| 4.1.5.9.2.6 | 5C1246 | Electronic calib | 53 | 2 | 02/06/04 | 02/09/04 |
| 4.1.5.9.2.6 | 5C1247 | Muon calibration #2 | 53 | 2 | 02/10/04 | 02/11/04 |
| 4.1.5.9.2.6 | 5C1248 | Mass properties #2 | 53 | 1 | 02/12/04 | 02/12/04 |
| 4.1.5.9.2.6 | 5C1250 | Vibration test | 53 | 3 | 02/13/04 | 02/18/04 |
| 4.1.5.9.2.6 | 5C1249 | 3 & 4 Thermal vac functional test | 75 | 10 | 02/19/04 | 02/28/04 |
| 4.1.5.9.2.6 | 5C1251 | Muon calibration #3 | 54 | 2 | 03/01/04 | 03/02/04 |
| 4.1.5.9.2.6 | 5C1252 | Comprehensive Functional Test #2 | 54 | 2 | 03/03/04 | 03/04/04 |
| 4.1.5.9.2.6 | 5C1253 | Preship review and signoff | 54 | 1 | 03/05/04 | 03/05/04 |
| 4.1.5.9.2.6 | 5C1254 | margin | 54 | 5 | 03/08/04 | 03/12/04 |
| 4.1.5.9.2.6 | 5C1254A | Ship to SLAC | 54 | 7 | 03/15/04 | 03/23/04 |
| 4.1.5.9.2.6 | 5C1254B | Post Ship Functional | 54 | 5 | 03/24/04 | 03/30/04 |
| 4.1.5.9.2.6 | 5C1255 | AV: Flight Calorimeter Tower 4 RFI | 54 | 0 | | 03/30/04 |



# Facilities

- **Assembly and test facilities**
  - **Naval Center for Space Technology**
  - **NRL Code 8000, Building A59**
  - **Assembly in 1000 sq. ft. clean room**
    - **Additional space available as needed**
  - **Environmental test**
    - **NCST facilities and experienced operators**



Thermal Vacuum test facility

Vibration test facility